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IS 13464 (1992): Polyamide (nylon 66) materials for moulding and extrusion [PCD 12: Plastics]

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# संचकन और बहिर्वेधन के लिए
# पालिएमाइड ( नाइलॉन 66 ) संचकन सामग्रियां — विशिष्टि

*Indian Standard*

# POLYAMIDE ( NYLON 66 ) MATERIALS FOR MOULDING AND EXTRUSION — SPECIFICATION

UDC 678·675·033·3

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BUREAU OF INDIAN STANDARDS
MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG
NEW DELHI 110002

*September 1992*

Price Group 3

Plastics Sectional Committee, PCD 12

## FOREWORD

This Indian Standard was adopted by the Bureau of Indian Standards, after the draft finalized by the Plastics Sectional Committee had been approved by the Petroleum, Coal and Related Products Division Council.

The term Nylon is applied to synthetic polyamides that have fibre, film and/or plastic forming properties. All 'Nylons' have in the polymer materials the amide ( —CO—NH— ) group, the link that joins the repeating hydrocarbon units of various lengths. The intermediates for nylons are dicarboxylic acids, diamines, amino-acids and lactums. Nylons are usually identified numerically using the number of carbon atoms in the basic units of the polymer chains. A duplex digit is used where the nylon is derived from a diamine and diacid, the first digit of the duplex referring to the diamine and the second digit referring to the diacid. For example, the polymer from hexamethylene diamine and adipic acid is termed as Nylon-66, that from hexamethylene diamine and sebasic acid Nylon-610, that from caprolactum Nylon-6.

Nylon possesses high impact resistance, toughness, low coefficient of friction, resistance to most common solvents, self extinguishing and possess good machinability.

Variations in moulding conditions produces more variations in all properties. To avoid this the material may preferrably be processed in screw type semi-automatic/automatic injection moulding machines where the temperature variations are controlled within ±5°C from the set point. The melt temperature of the polymer shall be as near to its melting point as possible.

Nylons should be melt processed at relatively low moisture content. Since nylons are hygroscopic, care shall be taken to ensure an adequately low moisture level normally not exceeding 0·2 percent. Resins from the manufacturer's package usually is dry enough but predrying is recommended on perforated trays where the resin is collected to a height not exceeding 2·5 cm for approximately 2 to 4 hours at temperature not exceeding 85°C in air circulating oven. Predrying can also be done safely at a faster rate in oven at a temperature ranging from 80 — 100°C for couple of hours.

The committee considered it relevant to include the various requirements of reinforced and filled nylons ( Nylon 66 ) which are widely used at present and has become popular since 1987. However, after generating sufficient data on the requirements to be met by the filled and reinforced nylons ( Nylon 66 ) and after development of the standardized test methods thereof, the same will be included at a later date.

For the convenience of fabricators details regarding post treatment of moulding namely, annealing, conditioning machining and service temperature are given in Annex A. In general, the maximum operating temperature ( continuous ) in case of Nylon-66 is observed to be 100°C.

For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test or analysis, shall be done in accordance with IS 2 : 1960 'Rules for rounding off numerical values ( *revised* )'. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

# AMENDMENT NO. 1 OCTOBER 2000
# TO
# IS 13464 : 1992 POLYAMIDE (NYLON 6) MATERIALS FOR MOULDING AND EXTRUSION -SPECIFICATION

*(Foreword, second para, fourth line )* — Substitute 'lactams' *for* 'lactums'.

( *Foreword, second para, last line )* — Substitute **'caprolactam'** *for* 'capfolactum'.

( *Foreword, third para, first line )* — ***Insert*** 'properties like' after 'Nylon possesses'.

( *Foreword, third para, last line )* — Delete 'possess'.

( ***Page*** 3, ***clause*** A-2.2, *third line )* — Substitute **'90°C'** for '80 to **90°C'**.

***(Page*** 3, ***Fig.*** 1) — Substitute **'60°C'** and **'20°C'** ***for*** **'60°'** and **'20°'**.

( ***Page*** 4, ***Fig. 2 )*** — Substitute **'WATER AT 90°C'** ***for*** **'BOILING WATER'**

( ***Page*** 4, ***clause*** A-3.1.1, ***line*** 7 ) — Substitute the following for the existing:

'Plastics 0.1 to 0.6 k **cal/M$^2$/°C'**.

( ***Page 5, clause*** A-3.2 ) — Substitute dash **'—'** ***for*** **'SI** No. (iii), (iv) and (v).

(Page ***5, clause*** A-4, ***seventh line )*** — Substitute **'stiff'** ***for*** 'liquid'.

(PCD12)

# Indian Standard

# POLYAMIDE ( NYLON 66 ) MATERIALS FOR MOULDING AND EXTRUSION — SPECIFICATION

## 1 SCOPE

This standard prescribes the requirements, methods of sampling and test for Nylon-66 materials for moulding and extrusion.

## 2 REFERENCES

The following Indian Standards are necessary adjuncts to this standard:

| *IS No.* | *Title* |
|---|---|
| 196 : 1966 | Atmospheric condition for testing |
| 867 : 1963 | Method of test for phenolic moulding materials |
| 2267 : 1972 | Specification for polystyrene moulding materials |
| 2824 : 1975 | Method for determination of comparative tracking index of solid insulating materials under moist conditions |
| 2828 : 1964 | Glossary of terms used in plastic industry |
| 3396 : 1979 | Method of test for volume and surface resistivities of solid electrical insulating materials |
| 4486 : 1967 | Recommended methods for the determination of the permittivity and dielectric dissipation factor of electrical insulating materials at power, audio and radio frequencies including meter wavelength |
| 4905 : 1968 | Methods for random sampling |
| 5210 : 1969 | High impact polystyrene sheet |
| 6746 : 1969 | Unsaturated polyester resin systems for low pressure fibre-reinforced plastics |
| 8543 ( Part 4/ Sec 1 ) : 1984 | Plastics — Methods of testing: Part 4 Short term mechanical properties, Sec 1 Determination of tensile properties |
| 13360 ( Part 1 ) : 1992 | Plastics — Methods of testing: Part 1 Introduction |
| 13360 ( Part 6/ Sec 6 ) : 1992 | Plastics — Methods of testing Part 6 Thermal properties, Sec 6 Flammability by oxygen index |
| 13360 ( Part 6/ Sec 10 ) : 1992 | Plastics — Methods of testing: Part 6 Thermal properties, Sec 10 Determination of melting point ( melting temperature or range ) |
| 13360 ( Part 5/ Sec 13 ) : 1992 | Plastics — Methods of test: Part 5 Mechanical properties, Sec 13, Determination of rockwell hardness |
| 13463 : 1992 | Specification for polyamide ( Nylon-6 ) materials for moulding and extrusion |

## 3 TERMINOLOGY

For the purpose of this standard, the definitions given in IS 2828 : 1964 shall apply.

## 4 REQUIREMENTS

### 4.1 Description

The material shall be in the form of granules/chips of natural colour unless otherwise specified by the purchaser. Size of the granules/chips are to be agreed between the purchaser and the supplier.

4.2 The material shall also comply with the requirements given in Table 1 when tested according to the method prescribed in col 4 and 5.

### 4.3 Colour

The colour/shade of the material shall be natural unless otherwise specified by the purchaser.

## 5 PACKING AND MARKING

### 5.1 Packing

The material shall be suitably packed in polyethylene bags in 10 kg tin containers or in polyethylene lined paper with multi-wall sacks or any other suitable method facilitating easy handling and providing protection against ingress of moisture.

### 5.2 Marking

Each container/package shall be clearly marked with the following information:

a) Indication of the source of manufacture;
b) Colour/shade;
c) Date of manufacture;

### Table 1 Requirements for Polyamide ( Nylon 66 ) Moulding Materials ( Unfilled Materials, Natural Colour )

( *Clause* 4.2 )

| Sl No. | Characteristic | Requirement | Methods of Test, Ref to | |
|---|---|---|---|---|
| | | | Indian Standard | Appendix/Clause |
| (1) | (2) | (3) | (4) | (5) |
| i) | Relative density at 27°C | 1·12 to 1·14 | 2267 : 1972 | A-9 |
| ii) | Melting point, °C | 255 to 265 | 13360 ( Part 6/Sec 10 ) : 1992 | Method A |
| iii) | Water absorption ( 24 h immersion at 27°C ), percent, *Max* | 1·4 | 13463 : 1292 | B |
| iv) | Rockwell hardness 'R' Scale, *Min* | 120 | 13360 ( Part 5/Sec 13 ) : 1992 | — |
| v) | Tensile strength at yield, MPa, *Min* | 74 | 8543 ( Part 4/Sec 1 ) : 1984 | — |
| vi) | Elongation at break, percent, *Min* | 40 | 8543 ( Part 4/Sec 1 ) : 1984 | — |
| vii) | Izod impact strength ( notched ), $KJ/m^2$, *Min* | 3·8 | 2267 : 1972 | A-6 |
| viii) | Flexural modulus, MPa, *Min* | 2750 | 5210 : 1969 | C |
| ix) | Heat deflection temperature under load | | | |
| | a) at 1·80 MPa, °C, *Min* | 75 | 6746 : 1972 | J |
| | b) at 0·45 MPa, °C, *Min* | 200 | | |
| x) | Flammability | | | |
| | a) Self-extinguishing | Self-extinguishing | 2267 : 1972 | A-1 |
| | b) Oxygen index, percent, *Min* | 25 | 13360 ( Part 6/Sec 6 ) : 1992 | |
| xi) | Dielectric strength KV/mm, *Min* | 16 | 4486 : 1967 | — |
| xii) | Volume resistivity, ohm-cm, *Min* | $10^{14}$ | 3396 : 1979 | — |
| xiii) | Tracking index, V, *Min* | 600 | 2824 : 1975 | — |
| xiv) | Relative viscosity at 25°C | 2·5 – 5·5 | 13463 : 1992 | C |

NOTE — The required values of all properties are for dry as moulded ( DAM ) materials having moisture content not more than 0·2 percent.

d) Month and year of manufacture;
e) Batch number; and
f) Net mass.

**5.2.1** The containers/packages may also be marked with the Standard Mark.

## 6 SAMPLING

For the purpose of ascertaining the conformity of a consignment of materials to this specification, the scale of sampling and criteria for conformity shall be as given in Annex B.

# ANNEX A

( *Foreword* )

## POST TREATMENT OF MOULDINGS

### A-1 ANNEALING

**A-1.1** Dimensional changes may also be exhibited by mouldings when they are subjected to high temperatures:

i) The release of strains introduced into the mouldings by different rates of contraction on cooling that is quenching strains.
ii) The rearrangement of the molecular orientation introduced during the flow of the molten material into the mould and frozen-in during cooling.

Quenching strains may be released and rearrangement of the molecular orientation may be accelerated by annealing the mouldings at temperature below the softening point of material The mouldings are immersed in non-oxidising fluids like synthetic microcrystalline waxes for 10 minutes per 3·2 mm section thickness at 160°C. The mouldings should be cooled slowly either in the heating fluid or in draught free surroundings.

### A-2 CONDITIONING NYLON

**A-2.1** Conditioning is a process in which moisture is added as rapidly as possible to dry articles. As a rule, conditioning is carried out until the moisture content of the article is in equilibrium with ambient conditions, which are characterized by a given temperature and relative humidity.

| | *Equilibrium Moisture Content at 23°C and 50 Percent RH* | *Immersed in Water* |
|---|---|---|
| Nylon-66 | 2·5 to 3·0 percent | 7·5 percent, *Max*, |

**A-2.1.1** The properties of dry nylon articles are different to those of moist. The absorption of moisture by dry articles during use thus often gives rise to impermissible changes in properties and dimensions, particularly in impact strength. In addition, a demand imposed on many machine parts is that their dimensions, strength and rigidity must remain constant within comparatively narrow limits. This may not be achieved unless the moisture content is close to the equilibrium value.

### A-2.2 Conditioning in Hot Water

The article is conditioned by immersing it in a covered insulated water bath that is thermostatically controlled at 80 to 90°C, and the amount of moisture pick-up may be determined simply by weighing. Conditioning in boiling water also acts as an annealing process. If the raw stock used for preparation of nylon articles by machining has not been conditioned by the manufacturer before hand, it should be treated at the very latest before it is machined for the last time.

An idea of the times required for conditioning as function of the wall thickness and conditioning temperature may be derived from Fig. 1 and Fig. 2.

There is not much point in over conditioning nylon articles that is having too high a moisture content. The excess moisture is again released until the value corresponding to that of the environment is attained.

### A-2.3 Moisture Equilization After Conditioning

It may be ascertained by weighing that an article conditioned does actually contain the desired amount of moisture. But this does not give any information how the moisture is distributed throughout the cross-section of the articles. Although all efforts are made to ensure uniform distribution, it is never really achieved immediately after conditioning unless the wall thickness of the articles is less than about 3 mm. In thicker articles just removed from the condition bath, the moisture content is much higher than desired in the superficial layers, and the core is almost dry. If articles of this nature are kept in air after conditioning, part of the water in the almost saturated superficial layer would escape to the air, and part of the excess would penetrate further into the dry core. Experiments have revealed that up to 50 percent of the water absorbed by thick articles during conditioning may be given off again. For this reason, it is advisable to keep nylon mouldings packed under moist conditions after conditioning namely, in polyethylene bags. There are no objections to the release of slight amounts of water from the saturated superficial layers because it has been demonstrated in practices that a moisture content of 2·5 percent is quite adequate in most cases for nylon-66 mouldings. This figure correspond roughly to equilibrium moisture content at 20°C and 40 to 50 percent relative humidity.

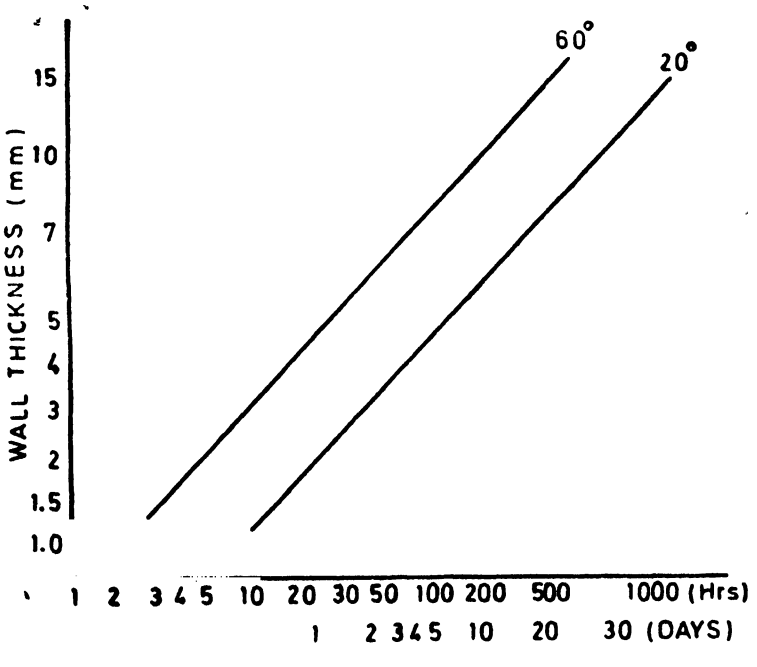
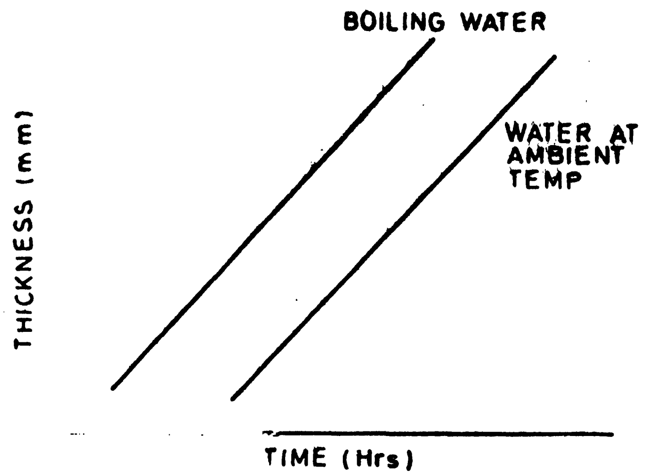


FIG. 1 CONDITIONING TIME IN WATER FOR DIFFERENT WALL THICKNESS



Media — Water, Temperature — Ambient/90°C, Time — Until a weight gain of 2·5 to 2·0 percent.

FIG. 2 CONDITIONING

### A-2.4 The Performance of Conditioned Articles

Moisture penetrates very slowly into dry articles kept in air. It is released from conditioned mouldings just as slowly if the ambient condition change. As a consequence, the moisture content of conditioned articles does not closely follow fluctuations in atmospheric humidity. In fact, there is a considerable lag. Since the change in lengths is small ( $\triangle V \simeq 3 \triangle L$ ) fluctuations in ambient conditions may usually be neglected in practice. For example, the moisture content of a 5 mm nylon 66 article would change by only about ±0·4 percent if it were exposed to long cycles of severe changes in ambient conditions. The associated change in length would be less than ± 0·23 percent ( $= 1/3 \triangle V$ ). As opposed to this, changes in dimensions caused by thermal expansion are of the order of 0·18 percent for change in temperature.

## A-3 MACHINING

**A-3.1** All the machining operations used in ordinary metal working may be applied to the nylons but the tools and their setting, speeds, feeds, etc, should be adapted to account for the differences in properties between metals and plastics.

### A-3.1.1 *Conductivity*

The low thermal conductivity of polyamides compared to metals reduces the rate of dissipation of the heat generated between the tool and the work piece and tends to create local overheating to the machined part.

Thermal Conductivity:

| | |
|---|---|
| Plastics | 0·1 to 0·6 K Cal/$m^2$/K. |
| Metals | 40 to 400 K Cal/$m^2$/°C. |

### A-3.1.2 *Melting Point*

The melting point of nylons is very much lower than that of any of the common structural metals. Thus the heat generated in machining tends to degrade, soften and even melt the nylon.

Polyamide ( Nylon 66 ) – 262 to 263°C.

### A-3.1.3 *Stiffness*

The room temperature stiffness of unfilled Nylons is much less than that of any of the metals commonly machined. At the elevated temperatures often generated by machining, the stiffness is even less; full support shall therefore be given to the work piece and low tool pressure employed when machining components where tight tolerances are to be maintained,

Unfilled Plastics : $E \simeq 100 - 4\,000$ MN/$m^2$
Filled Plastics : $E \simeq 1\,500 - 15\,000$ MN/$m^2$
Steel : $E \simeq 200\,000$ MN/$m^2$

### A-3.1.4 *Dimensional Changes Due to Moisture Absorption and Thermal Expansion*

Nylons starts to pick up moisture until they have reached equilibrium water content. A dimensional expansion accompanies water absorption but nylon undergo a far greater dimensional change as a result of thermal expansion. For example, a moulding takes approximately one year to absorb 3 percent moisture giving an expansion of 0·3 percent. The same moulding would experience a similar dimensional change when subjected to a temperature rise of about 30°C.

*Equilibrium Water Absorption*

Polyamide ( Nylon-66 ) : 2·5 to 3·0 percent at 23°C and 50 percent RH 3 to 10 percent *Max* immersed in water.

*Thermal Expansion*

Nylon-66 : 9 to 10 × $10^{-5}$/°C
Steel : 1 × $10^{-5}$/°C

**A-3.2** During machining take care of

- Sharp tools
- Low rates of feeding
- Good cooling ( Use cooling air jet or cooling fluids )
- Machining in steps
- Uniform, low clamping force
- Thin articles sometimes need:
  - i) Special support.
  - ii) Low tool leads.
  - iii) Deformation under load during machining.
  - iv) Elasticity recovery.
  - v) Chip formation, use chip deflector or select right cutting speeds.
- Blunt tools which rub and generate heat

## A-4 SERVICE TEMPERATURE

As the temperature increases and the modulus of elasticity thus, decreases, the risk of permanent deformation of moulding by stressing becomes greater. In this case, it is important to observe the heat distortion temperature, that is temperature at which the article is still sufficiently liquid to suffer no permanent deformation under normal internal stresses or external loads. The heat distortion temperatures of Nylon-66 is 140 to 170°C. Very slightly stressed loadings may withstand even higher temperatures in fact temperatures of more than 200°C and severely stressed articles may deform at temperature as low as 60°C.

# ANNEX B

( *Clause* 6 )

## SAMPLING OF POLYAMIDE ( NYLON 66 ) MOULDING MATERIALS

## B-1 GENERAL REQUIREMENTS OF SAMPLING

**B-1.1** Samples shall not be taken in an exposed place.

**B-1.2** The sampling instrument, which shall be made of glass, stainless steel or any other material on which polyamide moulding material has no action, shall be clean and dry.

**B-1.3** Precautions shall be taken to protect the samples, the material being sampled, the sampling instrument and the containers selected for sampling from adventitous contamination.

**B-1.4** To draw a representative sample, the contents of each container selected for sampling shall be mixed as thoroughly as possible by suitable means.

**B-1.5** The samples shall be placed in suitable, clean, dry, air-tight sheet metal or glass containers on which the material has no action.

**B-1.6** Each sample container shall be sealed air-tight with a stopper filling and marked with full details of sampling, the date of sampling and the month and year of manufacture of the material.

## B-2 SCALE OF SAMPLING

### B-2.1 Lot

All the containers in a single consignment of the material drawn from a single batch of manufacture shall constitute a lot. If a consignment is declared or known to consist of different batches of manufacture, the batches shall be marked separately and the groups of containers in each batch shall constitute separate lots.

**B-2.2** Samples shall be tested for each lot for ascertaining the conformity of the material to the requirements of this specification.

**B-2.3** The number of containers to be selected from a lot shall depend upon the size of the lot and shall be in accordance with the Table 2.

**Table 2 Number of Containers to be Selected**

| Lot Size | Sample Size |
|---|---|
| Up to 25 | 3 |
| 26 to 50 | 4 |
| 51 to 100 | 5 |
| 101 and above | 7 |

**B-2.4** These containers shall be chosen at random from the lot and in order to ensure the randomness of selection, the procedure given in IS 4905 : 1968 may be followed.

## B-3 TEST SAMPLES AND REFEREE SAMPLE

### B-3.1 Preparation

To prepare a set of test samples, draw with an appropriate sampling instrument, from freshly opened containers which have been selected for sampling, an equal number of scoopfulls of material from any point at least 75 mm below the surface and 75 mm above the bottom of large containers, and from any point at least 25 mm below the surface and 25 mm above the bottom of small containers. The sample prepared by mixing the portions from each container shall be not less than eight times the quantity which is estimated to be required for carrying number of reduced samples. Each set of these reduced samples shall constitute the test sample.

**B-3.2** Three sets of test samples, each not less than twice the quantity required for the purpose of testing, representative of each selected container ( *see* **B-3.1** ) shall be transferred immediately to thoroughly dried containers, which shall be sealed air-tight with an appropriate stopper. These containers shall be marked with all the particulars of sampling given under **B-1.6**. One set of the test samples shall be sent to the purchaser and one to the supplier.

### B-3.3 Referee Samples

The third set of the test samples, bearing the seals of the purchaser and the supplier shall constitute the referee sample, to be used in case of dispute between the purchaser and the supplier. It shall be kept at a place agreed to between the purchaser and the supplier.

## B-4 NUMBER OF TESTS

**B-4.1** Tests for all the requirements shall be conducted on composite samples.

## B-5 CRITERIA FOR CONFORMITY

**B-5.1** All the containers selected in col 2 of Table 2 shall be subjected to visual examination. The test on composite sample shall be conducted only when the material is found to be satisfactory after visual examination.

**B-5.2** The lot shall be declared as conforming to the requirements of this standard if all the test results conducted on composite sample satisfied the requirements given in Table 1.

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